Development of Novel Water-Gas-Shift Membrane Reactor for H_2 Enhancement

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- **Project Duration: 10/1/01 – 9/30/04**
- **Total Estimated Funding: $892,700**

Technical Goals/Objectives of Project

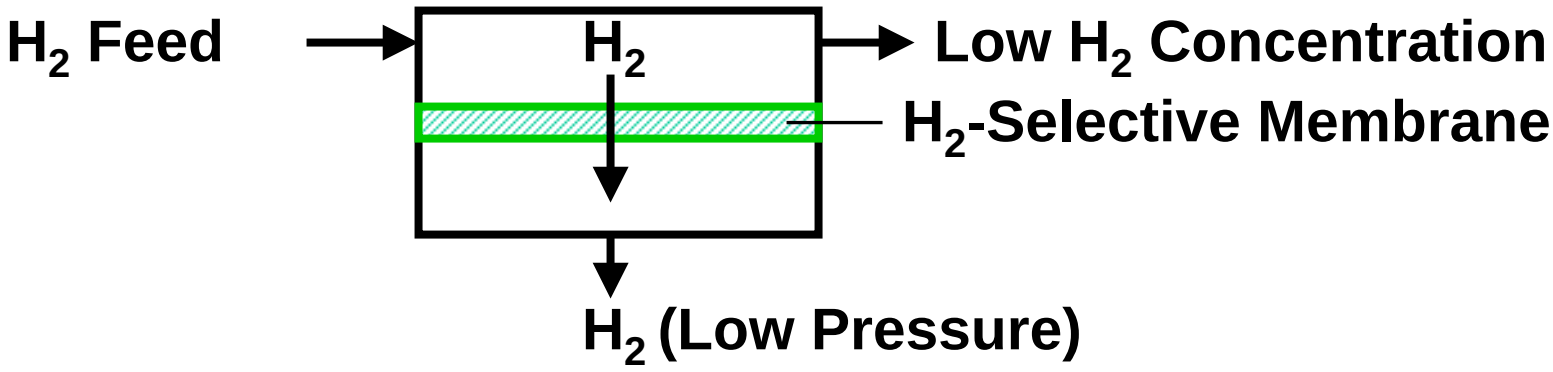
- **Use CO_2-Selective Membrane to Enhance Water Gas Shift (WGS) Reaction**
- **Develop Novel CO_2-Selective WGS Membrane Reactor**
  - **H_2 Enhancement via CO_2 Removal**
  - **CO Elimination to 10 ppm or Lower**
- **Deliverable: WGS Membrane Reactor for a 50 kW Fuel Cell (9/04)**

On-Board/Off-Board Purification of Reformed Gas with Membrane

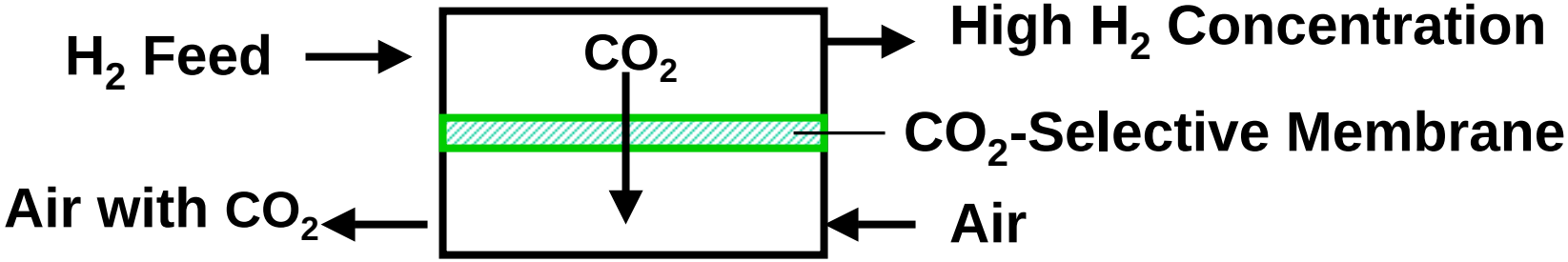
- **Light Weight**
- **Compact – Membrane Module**
- **Simple Operation**
  - **Pressure Differential**
  - **No Moving Parts**

Novel Membrane Process for H_2 Purification

- **Conventional / Commercial Membrane Process**



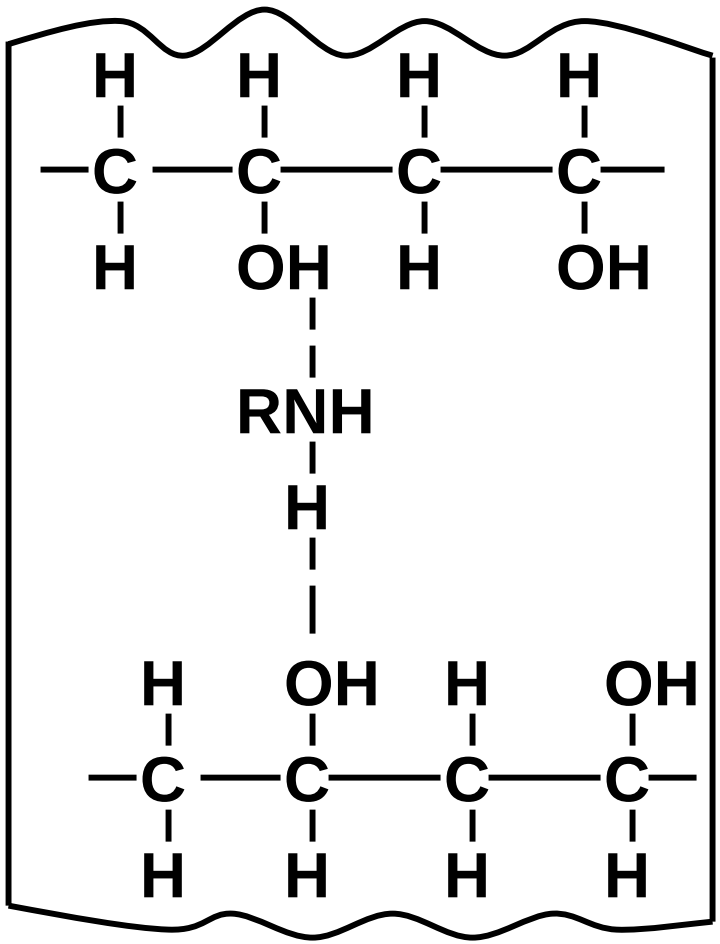
- **Novel Membrane Process**

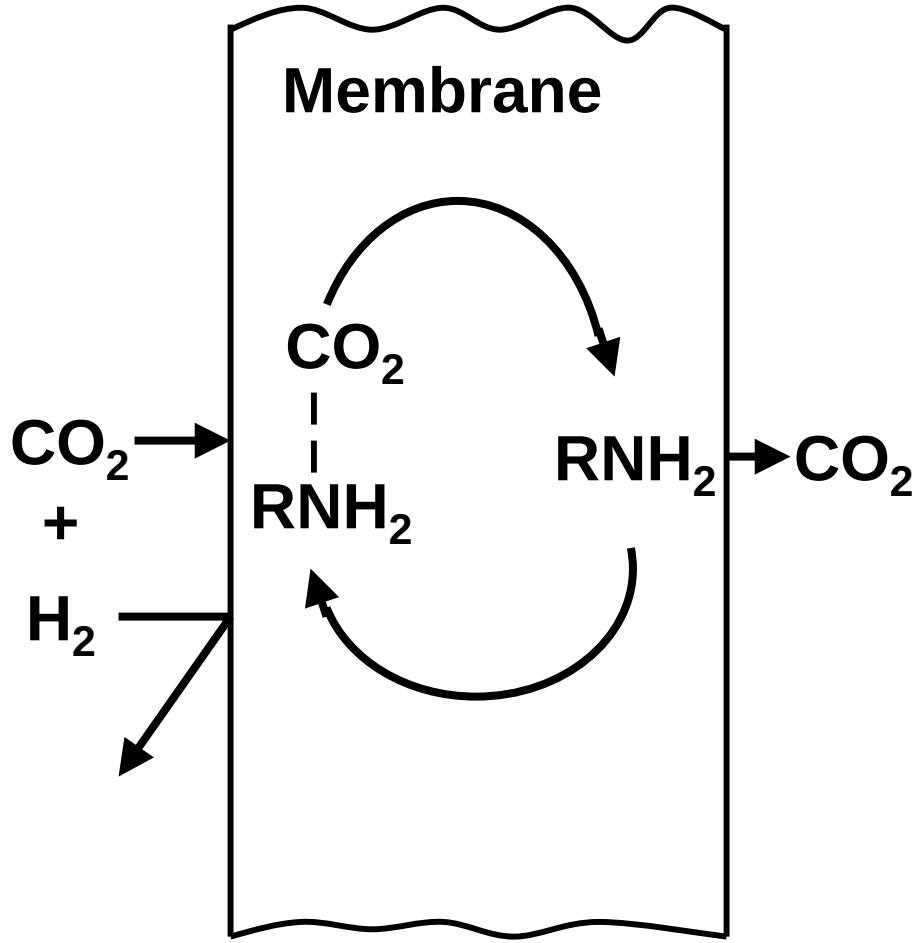


- High-purity H_2 Recovered at High Pressure
- High-purity H_2 Product without CO_2 Desirable
  + CO_2 acts as diluent / produces CO via reverse WGS reaction
- High H_2 Purity/Recovery via High Driving Force from Air Sweep
- Minimal Parasitic Power Required for Air Blown Separation

CO_2-Selective Membranes by Incorporating Amines in Polymer Networks … Facilitated Transport

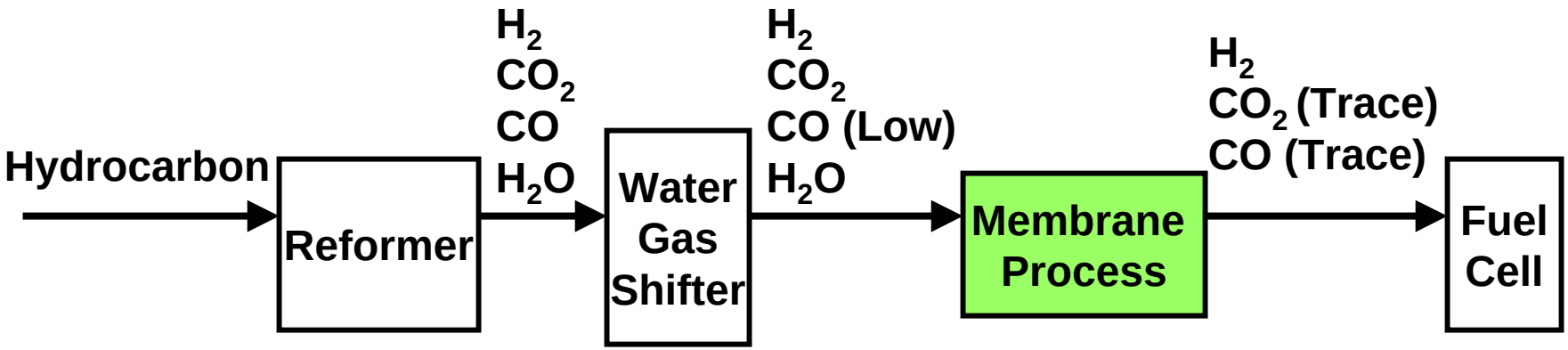
Example: Polyvinylalcohol-Containing Amine Membrane



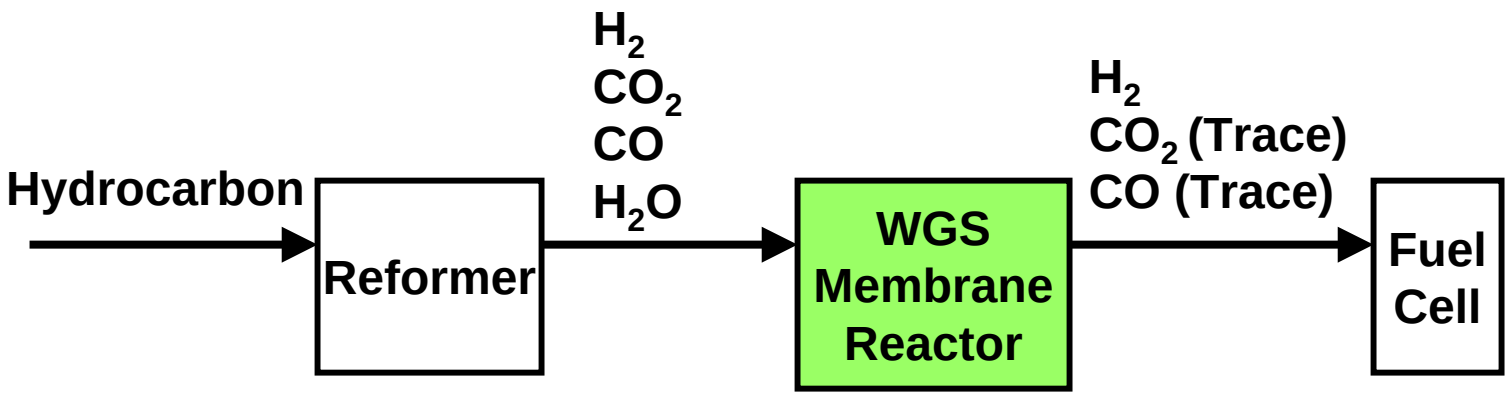


Fuel-Cell Fuel Processing with CO_2-Selective Membranes

- **Low Temperature CO_2-Selective Membrane**



- **High Temperature CO_2-Selective Membrane**



Summary of Work Plan

- **Phase 1 Tasks (10/1/01 –9/30/02)**
  - **Modeling Study / Technical Analysis**
  - **Economic Analysis / Benefits-Risk Assessment**
  - **Development of Novel Membrane**
  - **Characterization of Novel Membranes**
- **Phase 2 Tasks (10/1/02 –9/30/03)**
  - **Set-up of Membrane Reactor Apparatus**
  - **Membrane Fabrication for Reactor**
  - **Proof-of-Concept Demonstration**
  - **Use and Verification/Refining of Model**
  - **Design of Prototype Membrane Reactor**
- **Phase 3 Tasks (10/1/03 –9/30/04)**
  - **Set-up of Prototype Membrane Reactor**
  - **Fabrication of Prototype Membrane Module**
  - **Prototype Membrane Reactor Demonstration**

Project Schedule

Task	2001 4Q	1Q	2Q	2002 3Q	4Q	1Q	2Q	2003 3Q	4Q	1Q	2Q	2004 3Q
Phase 1 Tasks												
Modeling Study/Technical Analysis	———											
				Δ								
Development of Novel Membrane	———											
Characterization of Membranes	———											
Phase 2 Tasks												
Set-up of Membrane Reactor Apparatus					———							
Membrane Fabrication for Reactor					———							
Proof-of-Concept Demonstration						———						
								Δ				
Design of Prototype Membrane Reactor							———					
Phase 3 Tasks												
Set-up of Prototype Membrane Reactor									———			
Fabrication of Prototype Membrane Module									———			
Prototype Membrane Reactor Demonstration										———		
												Δ

Success for the Project

- **Technical Goals/Objectives Achieved**
- **Novel CO_2-Selective WGS Membrane Reactor Developed**
  - **H_2 Enhancement via CO_2 Removal**
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